NANOCRYSTALLINE DIAMOND ON CARBON NANOTUBES: TOWARDS A NEW CLASS OF CARBON NANOMATERIALS

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Recently, carbon nanotubes and nanodiamond have emerged as the more advanced and fascinating forms of crystalline carbons. The outstanding mechanical, chemical, electronic and thermal properties of these nanomaterials suggest wide applicability in advanced technological areas. However the control of growth locations and orientation of such nanostructures and the production of well defined architectures on micro- and nano-scale is necessary for the development of high performance materials.
In this context we have focused our research activity on establishing strategies for the generation of deposits of carbon nanotubes with controlled organization in terms of alignment, orientation and density. Moreover, the development of new experimental techniques has allowed us to produce coatings of nanocrystalline diamond (grain size in the range 5-50 nm) on carbon fibers [1].
In this communication we outline a methodology for the growth of nanodiamond on bundles of single-walled carbon nanotubes (SWNT). Using a CVD-based technique, metal-catalysed reactions of carbon species with hydrogen fluxes allow us to generate the two different phases during the same run. The reactants are atomic H and carbon nanopowders (mean diameter: 40 nm) carried by an Ar stream and delivered through a nozzle across the active area of the substrate, where the C nanostructures are deposited.

The substrates (Si plates coated by a sub-micrometer dispersion of Fe particles) can be translated and positioned at controlled distance with respect to the heated filament of the CVD reactor. Several characterization techniques (FE-SEM, TEM. RHEED, Raman spectroscopy) are used to monitor the structural evolution and the growth progression of both carbon nanophases in samples with growth time ranging from 1 to 15 minutes.

The SEM analysis of samples grown for times less than 2 min shows the initial formation of randomly oriented SWNTs assembled in bundles with diameters around 120 nm. After approximately 4 min the deposits are formed by nanotube bundles which begin to align parallel each other (self-assemble). In the samples grown for 6-8 min (Fig.1 a) the graphitic walls of the SWNTs appear covered by nanocrystalline grains with the typical features of diamond (s.g Fd3m) and after 10 min the diamond coverage is complete along the whole length of the SWNT bundles. At this stage the morphological characterizations evidence arrays of tubular structures covered by well shaped crystallites with diameters in the 20-100 nm range (Fig.1 b).
The dynamic of the process is found to depend on the relative abundance of atomic H impinging on the external surface of the nanotubes. First principle calculations carried out in order to investigate the effects of H adsorbates on SWNT walls indicated that the formation of C-H bonds disrupts locally the C-C sp^2 network and promotes the creation of suitable sites for diamond nucleation [2] .
These hybrid carbon nanostructures are extremely interesting materials for nanotechnology They are likely to find applications as efficient field- and electron-emitters but can also serve in mechanics, thermal management and sensing on a nanometer scale . The functional properties of carbon nanotubes coated by nanodiamond are presently under investigation in our laboratories.

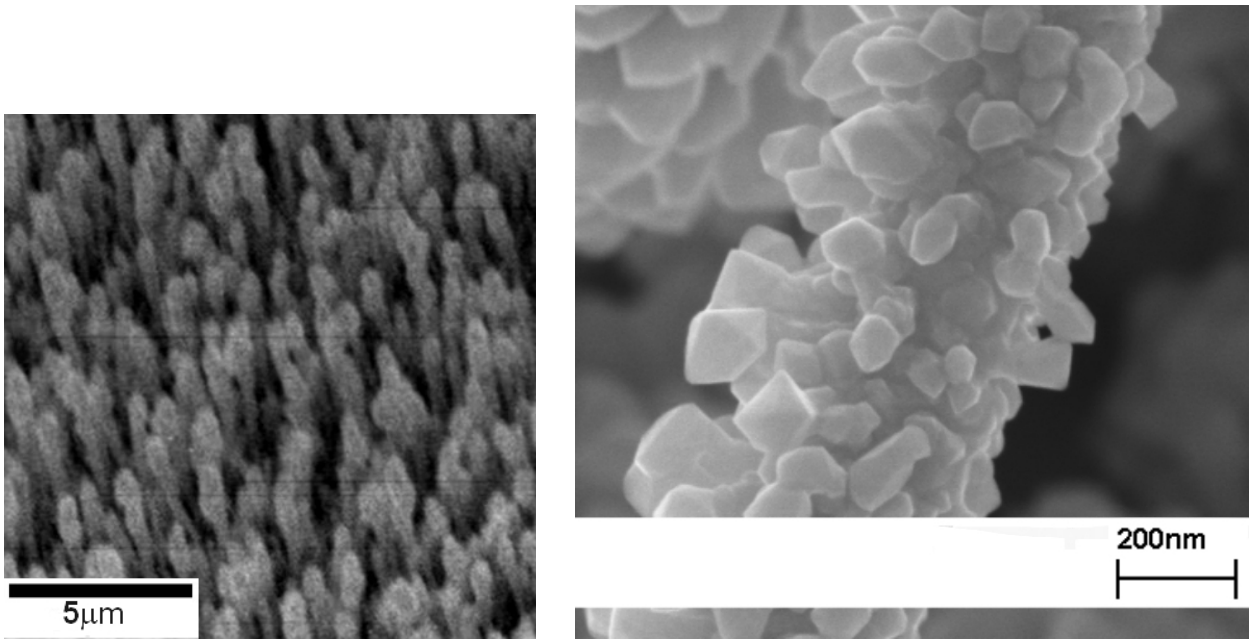

Fig.1 FE-SEM images: a) an array of nanotube bundles coated by nanodiamond; b) details of diamond nanocrystallites

REFERENCES

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